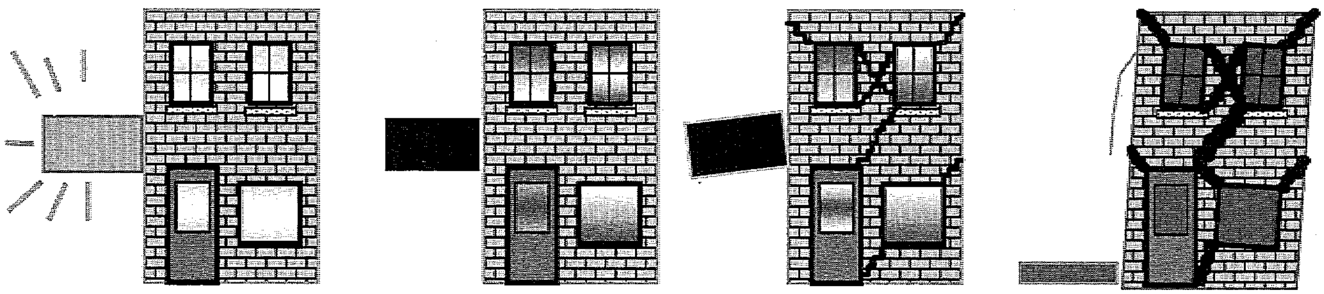
FEDERAL EMERGENCY MANAGEMENT AGENCY FEMA-349/April 2000

ACTION PLAN

FOR

PERFORMANCE BASED SEISMIC DESIGN



Prepared for the
Federal Emergency Management Agency
By the
Earthquake Engineering Research Institute

FORWARD

One of the primary goals of the Federal Emergency Management Agency (FEMA) is the prevention, or mitigation, of this country's losses from natural hazards. To achieve this goal, we as a nation need to ask what level of performance do we expect from our buildings during an event such as an earthquake. In order to answer this question, FEMA is exploring the possible development of "performance-based seismic design" criteria. Such criteria could be voluntarily used by this nation's engineers and designers to improve the performance of critical classes of buildings that are currently only designed to a "lifesafety" level to avoid collapse, but would in fact probably still suffer significant damage in a design event.

FEMA contracted with the Earthquake Engineering Research Institute (EERI) (contract number EMW-92-K-3955, Task 13) to solicit the input of the nation's leading seismic professionals in developing an action plan that could be used to develop performance-based seismic design criteria. This project and the resulting action plan have gone a long way in identifying key issues that will need to be addressed in this process.

This action plan builds upon a similar effort that FEMA funded in 1993 with the Earthquake Engineering Research Center, now the Pacific Earthquake Engineering Research Center (PEER). The end product of that study was a similar plan, "Performance Based Seismic Design of Buildings" (FEMA-283), published by FEMA in September 1996. The material in that plan had an emphasis on the research that would be required, and has in fact been used by PEER in the last several years as the basis for their research work in this arena.

While this action plan does an excellent job of describing the requirements that would be needed to successfully develop performance based seismic design criteria, FEMA does has some concerns, such as the proposed budget, which exceeds what FEMA is capable of devoting within the recommended time frame. FEMA is planning to identify some of the key elements of the plan and to begin to address them through a series of projects under its Problem Focused Studies program. However, without additional specific funding for this plan, it will be very difficult to accomplish the entire plan. To avoid further delay, FEMA has decided to publish this document as a "final draft" for informational purposes only. Publication of this document in no way obligates this or any other Federal agency to any portion of plan contained herein. The information and opinions contained in this document are solely those of EERI and the project participants and do not necessarily represent the views of FEMA.

In closing, FEMA sincerely wishes to express its gratitude to all who were involved in this project. The results of their hard work will play an important role as this country moves forward towards performance-based seismic design and reducing the losses suffered by this nation's citizens after the next earthquake.

Cover Art: Part of a presentation developed by Ronald O. Hamburger, EQE International

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Executive Summary

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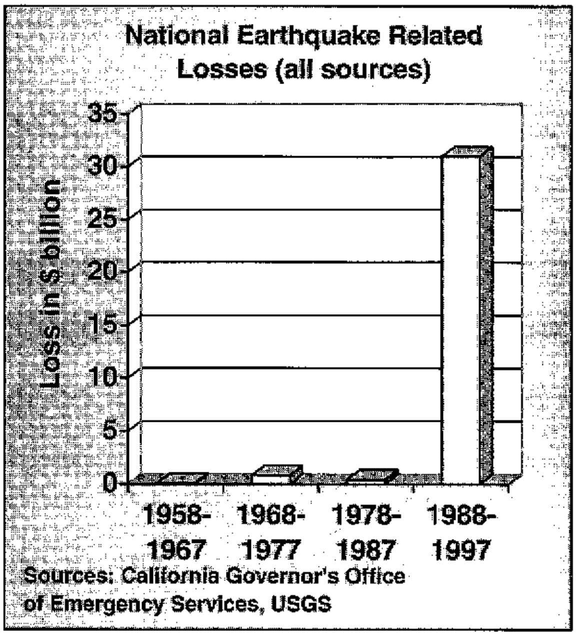
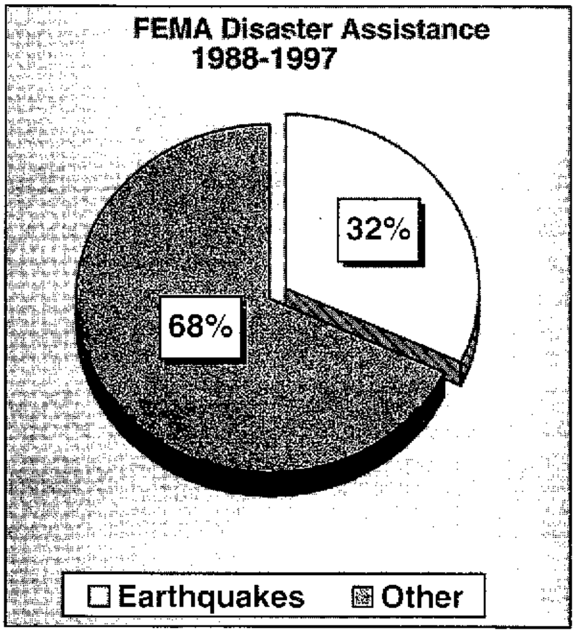
The Need for Changes in Current Seismic Design Practice

Recent decades have seen a dramatic rise in insured and uninsured earthquake related losses. In the past ten years estimated losses were twenty times larger than in the previous 30 years combined. FEMA's expenditures related to earthquake losses have become an increasing percentage of its disaster assistance budget.[1] Predictions are that future single earthquakes, which will inevitably occur, may result in losses of $50-100 billion each.[2]





Losses are rising due to several factors. These include: a denser population of buildings being located in seismically active regions, an aging building stock and the increasing cost of business interruption. Nonstructural and contents damage are also large contributors to loss, especially in regions with high-technology manufacturing and health-care industries.

It is this increase in losses from all hazards that has led FEMA to support actions to reduce future losses. One of these is Project Impact, an initiative to encourage loss reduction activities through partnerships at the local community level. One of the key components of Project Impact is the community's adoption and enforcement of an adequate building code

Historically, building codes have required that buildings be built to a minimum level of safety. Specifically, structures designed to the Uniform Building Code are expected to "resist a minor level of earthquake... without damage,...a moderate level.. with some nonstructural damage, [and] a major level of earthquake...without collapse."[3]

Deaths in recent California earthquakes have been few, showing that the intent of the code has been met. However, there is a major misperception on the part of many owners, insurers, lending institutions and government agencies about the expected performance of a code conforming building. This has led to losses that were unexpected and in many cases financially ruinous. Building stakeholders--those with a financial or social interest in the built environment--who expect that their buildings are "earthquake proof" because they meet the code, have often been very disappointed. It must be said, too, that none of these recent events has been of an intensity that would typically be considered catastrophic. Catastrophic temblors with a magnitude similar to the 1812 New Madrid or 1906 San Francisco earthquakes will now likely result in losses several times larger than anything previously experienced if they occur in a densely populated area.

Many building owners are unaware of the tradeoffs they face when using the current state of design practice. Interestingly, people make similar tradeoffs with more everyday choices. For example, the number of highway fatalities could be dramatically reduced if everyone drove tanks. Yet most people are unwilling or cannot afford to do so, and instead accept the increased risk of driving a car. Consciously or not, car buyers perform cost-benefit analyses when weighing the risk of an accident against a car's cost. A careful consumer may decide to spend more to buy a safer car or he may opt to spend the same amount of money, but research much more closely the safety records of similarly priced cars. This consumer is reducing risk either by increasing his investment or by reducing his uncertainty.

Current codes clearly serve an essential and effective role in protecting building occupants. The design basis of the code is intended to provide a basic level of safety and a relatively economical means by which to construct buildings. However, using current code methods to design and build to a higher level of performance may add significantly to a project's cost.

Stakeholders, however, have become painfully aware of the financial and social consequences of earthquakes and are demanding that practical and cost-effective means be developed to address the issues of damage control and loss reduction.

The community of design professionals needs to be able to respond to this demand with the development of design and evaluation methodologies that look at a broad range of building performance and construction techniques.

Current codes represent an evolution of prescriptive rules that have changed every three years as more is learned about building behavior. The expected performance of new code designed buildings is poorly understood, and probably inconsistent among building types. It is currently difficult for rational advanced design techniques and innovative systems to be fit into the code framework. It is also difficult to apply building codes for new buildings to evaluation and retrofit of existing buildings. Special guidelines have been developed for these purposes, potentially creating a double standard.

Performance Based Seismic Design (PBSD) is a methodology that provides a means to more reliably predict seismic risk in all buildings in terms more useful to building users. It permits owners to:

- Make an efficient use of their design and construction budgets, resulting in more reliable performance for the money spent.

- Consider spending more money to achieve quantifiably higher performance than provided for in the code, thereby reducing risk and potential losses.

PBSD will benefit nearly all building users. The PBSD methodology will be used by code writers to develop building codes that more accurately and consistently reflect the minimum standards desired by the community. A performance based design option in the code will facilitate design of buildings to higher standards and will allow rapid implementation of innovative technology. When performance levels are tied to probable losses in a reliability framework, the building design process can be tied into owner's long-term capital planning strategies, as well as numerical life cycle cost models.

PBSD is not limited to the design of new buildings. With it, existing facilities can be evaluated and/or retrofitted to reliable performance objectives. Sharing the common framework of PBSD, existing buildings and new buildings can be compared equitably. It is expected that a rating system will develop to replace the currently used *Probable Maximum Loss* (PML) system. Such a system is highly desirable to owners, tenants, insurers, lenders, and others involved with building financial transactions. Despite its inconsistency and lack of transparency, the PML system is widely used and a poor rating often creates the financial incentive needed for retrofit decisions.

PBSD will provide a common base for design of new buildings, evaluation of existing buildings, and prediction of future damages. This will enable the results of regional loss estimates to be directly interpreted in terms of building code and retrofit strategies. PBSD will thus support and encourage efficient mitigation on both an individual and a regional scale, resulting in safer and economically stronger communities.

The availability and use of PBSD will also allow building owners and a local community to determine the performance level of buildings within their jurisdiction. This is especially true for structures that are critical to the continued function and livability of a community. For this reason, PBSD can play a significant role in meeting the intent and goals of FEMA's Project Impact initiative to reduce future losses.

This *Action Plan* presents a rational and cost effective approach by which building stakeholders: owners, financial institutions, engineers, architects, contractors, researchers, the public and governing agencies, will be able to move to a performance based design and evaluation system.

The Plan recognizes that there is a strong demand from stakeholder groups for more reliable, quantifiable and practical means to control building damage. It also recognizes that there is not a focused understanding among these groups as to how these goals can be obtained. This Plan describes how performance based seismic design guidelines can be developed and used to achieve these goals. It will be a vehicle to bring together the diverse sets of demands from within the stakeholder groups and distill them into cohesive and practical guidelines. It engages each of the groups in the development these guidelines, by which future building design will become more efficient and reliable.

What is Performance Based Seismic Design (PBSD)?

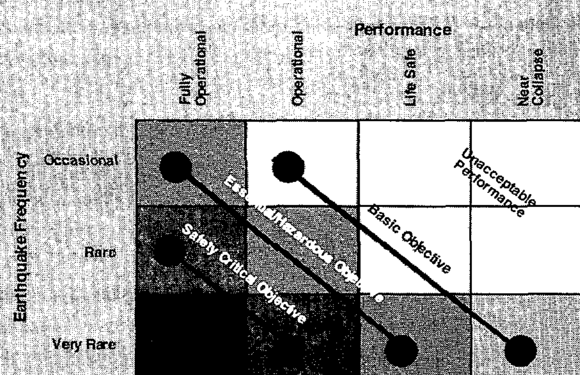
The basic concept of performance based seismic design is to provide engineers with the capability to design buildings that have a predictable and reliable performance in earthquakes.[4] Further, it permits owners and other stakeholders to quantify financially or otherwise the expected risks to their buildings and to select a level of performance that meets their needs while maintaining a basic level of safety.

PBSD employs the concept *of performance objectives*. A performance objective is the specification of an acceptable level of damage to a building if it experiences an earthquake of a given severity.[5] This creates a "sliding scale" whereby a building can be designed to perform in a manner that meets the owner's economic and safety goals. A single performance objective that requires buildings remain operational even in the largest events, will result in extraordinarily high costs. Conversely, a design where life safety is the only consideration may not adequately protect the economic interests of building stakeholders.

A key to knowing how a building will perform in a given earthquake is having the ability to estimate the damage it will sustain and the consequences of that damage. Current codes do not evaluate a building's performance after the onset of damage. Instead, they obtain compliance with a minimum safety standard by specifying a design which historically has protected life safety in earthquakes. In some cases, the code may actually be unconservative, if a building's irregularities are very substantial, or if a higher performance level such as damage control is the desired.

The Concept of Performance Objectives

Recently, the SEAOC Vision 2000 and FEMA 273 projects have described one concept of performance based seismic design. In the chart below, performance is shown on the horizontal axis (with increasing damage to the right) and the severity of earthquake (in terms of frequency) is shown on the vertical axis. Each square represents a *performance objective*: a performance state at a given earthquake intensity. The diagonal lines represent design criteria that an owner might impose on the building. For example, the most cost-effective design for a retail store might be to the "basic" criteria, whereas a high-tech manufacturer may want the reduced risk obtained with the "essential/hazardous" criteria. A local jurisdiction, on the other hand, may require that a hospital meet the "safety critical" criteria.



Source, Vision 2000

PBSD differs from current codes in that it focuses on a building's individual performance. It provides a road map that permits design professionals, owners and other stakeholders to learn more about a building's performance in different earthquakes, and implement a design that optimizes design and construction costs with respect to life-cycle performance. In its broadest sense, PBSD creates global planning opportunities for reducing economic and social losses to whole communities, regions and states.

To implement PBSD several issues must be resolved. PBSD will change the way stakeholders look at the built environment. It will require a comprehensive effort to bring the various interested parties to a consensus. Six challenges to adoption exist. They are:

- Increasing the current knowledge base of building behavior. This fundamental issue will require that broader and more accurate information be developed and collected on structural and nonstructural performance.
- Raising awareness among stakeholders about how PBSD can address many of the problems they already perceive with current design practice.
- Developing PBSD to be compatible the stakeholders' economic interests.
- Communicating the complex concepts and information in a way that is understandable to all stakeholders.
- Reducing uncertainty about how PBSD will effect stakeholders, in terms of cost and possible changes in liability exposures.
- Implementing incremental changes in the current standards, to create a continuum of design improvement rather than a perceived radical change.

This *Action Plan* identifies the specific tasks required to develop a cohesive set of products and guidelines that will meet these challenges. These products will be more than just technical documents. The Plan calls for going beyond earlier and more purely analytical performance based efforts by creating education and implementation programs to bring all stakeholders on board.

This Plan is to be used by the teams developing the guidelines. It will provide a mechanism to ensure that the goals of PBSD are being tracked. It encourages creativity while capturing the required elements of a successful program. For each of the products, a proposed budget and schedule are presented. A priority is assigned to individual tasks so that the program can be tailored to an overall funding level.

A Successful Use of PBSD

A major institution recently completed the seismic retrofit of a four-story concrete frame building using PBSD. The building was considered to represent a life safety hazard in the event of a large, nearby earthquake. The expected loss of lives and capital was unacceptable. A conventional, code based strengthening scheme would have resulted in such a high retrofit cost that replacing the entire facility might have been more practical. The cost and temporary loss of operations during replacement, however, were unacceptably high.

Using PBSD, engineers evaluated the building's performance, identifying the specific elements that contributed most to expected loss. A strengthening methodology was devised which focused on protecting these elements. To educate local building officials and the building users, the engineers made several presentations describing the methodology. The resulting design cost was less than one-third of the conventional scheme and required no disruption to the occupants. In fact, the strengthening is expected to produce a performance that exceeded the owner's minimum requirements. Formerly, this building represented a significant fraction of the institution's total expected earthquake losses. Now, the owner will be able to reallocate its limited emergency disaster funds to the next most needy facilities.

Products Necessary to Implement Performance Based Seismic Design

Six "products" are needed to create a PBSD standard that is comprehensive and acceptable to stakeholders. They are:

1. A **Planning and Management Program.** Currently there is a demand within the stakeholder community for more reliable ways to predict and control building performance. These demands, however, are not clearly articulated and are often conflicting. Clearly, though, there is increasing recognition that problems exist with current design practice. The greatest challenge to creating a successful PBSD program is distilling the most important needs within these demands and synthesizing from them a cohesive guideline for performance based design. A significant effort will be required to ensure that the PBSD guidelines respond to these needs fairly, are accepted by stakeholders and are implemented effectively. The *Action Plan* must be a vehicle to communicate these needs to the entire community, so that the solutions are appropriate and widely acceptable. A formal program will be necessary to educate people about how PBSD can respond to many of their current demands for more reliable and cost effective performance. The Planning and Management Program will consist of the following components:

➢ A **steering committee** to shepherd and promote the development of the Guidelines. This group will be responsible for insuring that the efforts by the various working groups are tracking towards the goals laid down in this *Action Plan*. It will work collaboratively with the stakeholders to create an effective coalition of interests. It will question stakeholders directly in a series of forums about what they see as concerns and benefits. This group needs to function as facilitators and encouragers to promote adoption.

➢ An **education strategy** to facilitate the use of the Guidelines. This will require a concentrated effort including conferences, workshops and publications to raise awareness and assist stakeholders in using the guidelines. Integration of the guidelines into codes and practice, and adoption by local and state jurisdictions needs to be accomplished in an incremental way yet with a defined timetable and strategy.

2. **Structural Performance Products (SPP)** The **SPP** will form the core reference material for the guidelines. They will consist of technical documents that quantify performance levels, define how to evaluate a building's performance, and develop methods for designing a structure to meet a performance level with defined reliability. They will present the necessary analytical information needed by engineers. A goal is to address new and existing buildings so that the guidelines will be appropriate for new design as well as retrofit. The creation of these products will require major technical research in order to

produce a comprehensive framework for structural design.

3. **Nonstructural Performance Products (NPP)**The **NPP** function similarly to the **SPP** but focus on the nonstructural components of a building: partitions, piping, equipment, contents, etc... In the 1994 Northridge Earthquake, several prominent buildings had significant losses not because of structural damage, but because of nonstructural damage such as broken sprinkler pipes. To truly achieve a desired performance, design of nonstructural components is as critical as the design of the structure itself. Engineers from many disciplines, architects and manufacturers who design and supply a building's nonstructural components will develop these products. Like the **SPP**, the **NPP** will require significant research, especially in the areas of equipment testing and certification. Also like the **SPP**, the **NPP** must include research focused on existing building stock.

4. **Risk Management Products (RMP)** The **RMP** are the key to bringing owners, financial institutions and governing agencies into the PBSD process. These documents will be financially oriented and will develop methodologies for calculating the benefits of designing to various performance objectives and for selecting appropriate design bases for individual and classes of buildings. The goal will be to provide a basis for stakeholders to make rational economic choices about the level of performance and the comparative costs to reach those levels.

5. The **PBSD Guidelines.** The PBSD Guidelines will be the actual document used by design professionals, building officials, material suppliers and equipment manufacturers to implement performance based design. It will distill and synthesize information from the **SPP, NPP** and **RMP** into one document that is usable by each of the groups. It is intended that this document will be published as a FEMA guideline and will serve as a basis for codes and practice thereafter. The guidelines will contain a technical commentary for reference. It will address new design as well as retrofit and it will serve as a basis for development of building "rating" systems, to provide financial guidance to stakeholders.

6. **A Stakeholders' Guide.** This document will function as a non-technical commentary to the Guidelines, explaining PBSD and providing instruction to the non-technical audience. PBSD will require a shift in the role owners, lending institutions and others play within the design process. These stakeholders will now be a fundamental part of developing the design strategy. The Stakeholders' Guide will help these groups choose objectives that best meet their cost and performance goals.

Schedule and Budget

Given adequate funding, implementation of the *Action Plan* can occur over a ten-year period. This is an ambitious schedule, as the products require major research and consensus building efforts. The steering committee will be a constant throughout the process, to facilitate and coordinate the various products. The products will be developed somewhat concurrently, with the Structural and Nonstructural Performance Products and the Risk Management Product leading the Guidelines and the Stakeholders' Guide. At milestones throughout the project, drafts of the Guidelines and Stakeholders' Guide will be prepared using information from the technical products. The provisions will be verified through example applications and stakeholder review, resulting in refinement or modification of the research efforts. In this way, the project will remain on track and under the scrutiny of the involved stakeholders. Throughout the project, the Planning and Management Program must be developed and employed, in order to gain acceptance from the stakeholders. In order to achieve wide acceptance of PBSD, it is imperative that participation be sought from a diverse group of stakeholders in broad geographical regions, and from both small and large businesses and municipalities. The participants must have the skills needed to develop each product, and represent as many points of view as possible.

The costs shown below are given as a range, the lower number representing the minimum essential funding level required to obtain a basic framework for PBSD, and the higher number representing the optimal level needed for full and effective implementation. Within the *Action Plan* a more detailed breakdown of the costs is presented, describing the specific tasks associated with each product, along with a flowchart describing the relationships between the six products. Priorities are attached to each task so that funding decisions can be made more easily.

Cost	Product	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
\$3.8-4.3	Planning and Management Program										
\$6.0-7.5	Structural Performance Products										
\$3.0-4.6	Nonstructural Performance Products										
\$2.8-4.6	Risk Management Products										
\$3.5-4.4	PBSD Guidelines										
\$1.2-1.9	Stakeholders' Guide										
\$20.4-27.3		1.1	2.1-2.4	2.0	2.4-2.9	2.0-2.8	2.6-3.9	2.1-3.0	2.5-3.6	2.1-2.8	1.5-2.7

Range represents essential and essential + optimal tasks
Amounts shown are in 1998 dollars

Conclusion

Few lives have been lost in major seismic events, in buildings designed under modern codes. The economic losses in recent earthquakes, however, have put a strain on communities, owners, lenders, insurers, governments and building users. The process of building design and construction must undergo a significant change in order to reduce future losses to these stakeholders. Current codes simply are not sophisticated or robust enough to allow designs to be refined to the extent that loss prediction and reduction are reliable.

Performance based seismic design has been in development for several years and represents a necessary strategy for reducing earthquake losses. It focuses on the economic and social goals of building stakeholders and integrates financial modeling with the latest engineering research. The various efforts within PBSD, however, have yet to be fully developed and synthesized into a comprehensive workable guideline. This major step is key to fulfilling the promise of PBSD and reaping its benefits.

This *Action Plan* lays out a rational, cost-effective and achievable program for establishing and implementing PBSD in a manner that will benefit each of the groups with a stake in the built environment. On an individual building basis and on community, county and statewide levels, PBSD offers opportunities to more reliably predict building performance and to reduce the social and economic impacts of earthquakes.

PBSD – A Regional Perspective

Stanford University is a microcosm of many large, highly developed, communities. It comprises nearly 900 buildings and over 12 million square feet of residences, classrooms, auditoriums, laboratories, and administrative buildings. The total population, including students, faculty and staff exceeds 20,000. The building inventory is diverse, ranging in age from over 100 years old to brand new and including masonry, concrete, steel, and wood frame construction.

Stanford, located less than five miles from the San Andreas Fault, faces a considerable seismic hazard. In a large nearby earthquake, the exposure--human lives, capital investment, and business income--is sizable. To reduce potential losses, the University has been using some of the fundamental concepts of PBSD on a campus-wide level to rehabilitate existing and build new facilities for nearly ten years. The total investment amounts to hundreds of millions of dollars.

Over time, PBSD at Stanford has evolved from an innovative standard for retrofit of hazardous existing buildings into a regional planning tool. Engineers identify specific risks associated with individual buildings using performance based evaluation techniques. Concurrently, university planners and managers establish the relative importance of their facilities in terms of occupancy load, replacement value, and impact on the academic mission. There are two important results of this process. First, Stanford optimizes mitigation funding by investing where the reduction in potential losses is most productive. Second, Stanford knows what to expect when it comes to response and recovery planning for earthquakes.

The experience at Stanford illustrates both the usefulness of PBSD and its long-range possibilities - safer and economically stronger communities.

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See *Action Plan* for additional references

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I Introduction

This *Action Plan* provides as its primary goal:

A strategy, definable tasks, a budget and a schedule for the development and implementation of usable and widely-acceptable performance based seismic design (PBSD) guidelines.

The Plan can function as a road map for the teams of people who will eventually create and implement these guidelines. The guidelines will provide a means for moving from the current practice of building design and construction intended primarily to protect life safety, to a system that also addresses the protection of the economic welfare of the public. It is not intended that this Plan limit the creativity of the development teams. Rather, it should serve as a means to track progress toward the project's goals, and offer guidance about the major challenges along the way. In fact, the Plan encourages innovation in the design and analysis of building systems, and in the way we view the relationships between members of the building development community.

The current state of the art contains valuable and practical information that has been implemented on some individual projects. A goal is to use this information where possible, filling in the gaps with new research and evaluation methods. References are included at the end of the document which describe the historical issues surrounding PBSD.

This document is, as its name implies, an *action plan*, focusing on the specific tasks that must be accomplished to implement PBSD broadly. The Plan centers about development of six "products," which are considered necessary for the full, effective adoption and implementation of PBSD. Each contributes to meeting a specific portion of the primary goal. The term "product" does not refer exclusively to written documents, but implies any means by which information is delivered to the intended audience. The products may also include presentations, workshops, audio/visual material, ad-hoc committees, teaching materials, etc.

An important challenge to implementing PBSD is overcoming the perception that it is only of benefit and interest to structural engineers and always adds cost to a project. To be successful, PBSD must come from and be embraced by the full spectrum of "stakeholders" within the building development community. The term "stakeholder" refers to owners, engineers, architects, researchers, financial institutions, materials suppliers, contractors, building officials, government agencies, and the building occupants: in essence, society at large. This obviously is a large group, but buy in from each is vital if PBSD is to work.

In fact, many of these groups are already calling for changes to the current state of design practice, and asking for more reliable ways to predict and control building performance. The *Action Plan,* therefore, solicits the involvement of each group. The Plan holds as a basic philosophy that the development of the products should not be dominated by one group. Clearly, each will have areas of expertise, but at all levels, an equal measure of respect is important in obtaining broad acceptance. PBSD, in its broadest sense, should be used as a global planning tool for large businesses, cities, counties and states.

At its heart, PBSD requires stakeholders to look differently at the built environment. By definition, it implies multidisciplinary collaboration to insure that buildings are built more efficiently, reliably and with predictable performance.

Product Summary

Each of the six products and the tasks and budget associated with its development is presented in a separate section. It is important to understand how each will come together to build a working framework for PBSD.

The six products are described below. The first product tracks through the entire project, shepherding the development of the other products and obtaining stakeholder support.

- **Planning and Management Program.** A formal program will be developed to educate stakeholders about PBSD. The Planning and Management Program will be implemented by a **steering committee** to shepherd and promote the development of the Guidelines and an **education strategy** to facilitate their use and adoption. The goal will be to ensure that the project accomplishes its purpose and that it is accessible and relevant to the stakeholders.

The next three products form the core technical basis for the guidelines. They will require substantial research, analysis, verification and possibly testing.

- **Structural Performance Products (SPP).** The **SPP** will quantify methods for predicting structural performance for various levels of seismic hazard. They will contain design and evaluation methodologies for both new and existing buildings. A focus of the research will be to increase reliability in the design and analysis process, thereby reducing uncertainties. Effort will be made to address existing as well as new construction. Early in the development of this product, an effort will be made to address the current state of the art and inherent uncertainties and gaps therein, and from that identify research needs and goals appropriate to reducing these uncertainties and gaps.

- **Nonstructural Performance Products (NPP).** The **NPP** function similar to the **SPP** but focus on the nonstructural components of a building: partitions, piping, equipment, contents, etc. The **NPP** should address new components and components already in place within existing buildings. Development of guidelines for component testing and certification will be part of these products. The goals and scope of separately funded programs to collect information on performance in past and future earthquakes and to test equipment will also be developed. Similar to the SPP, an initial effort will be made to assess the state of the art and develop a research plan.